# Simplifying interactions between autonomous and conventional ships with e-Navigation


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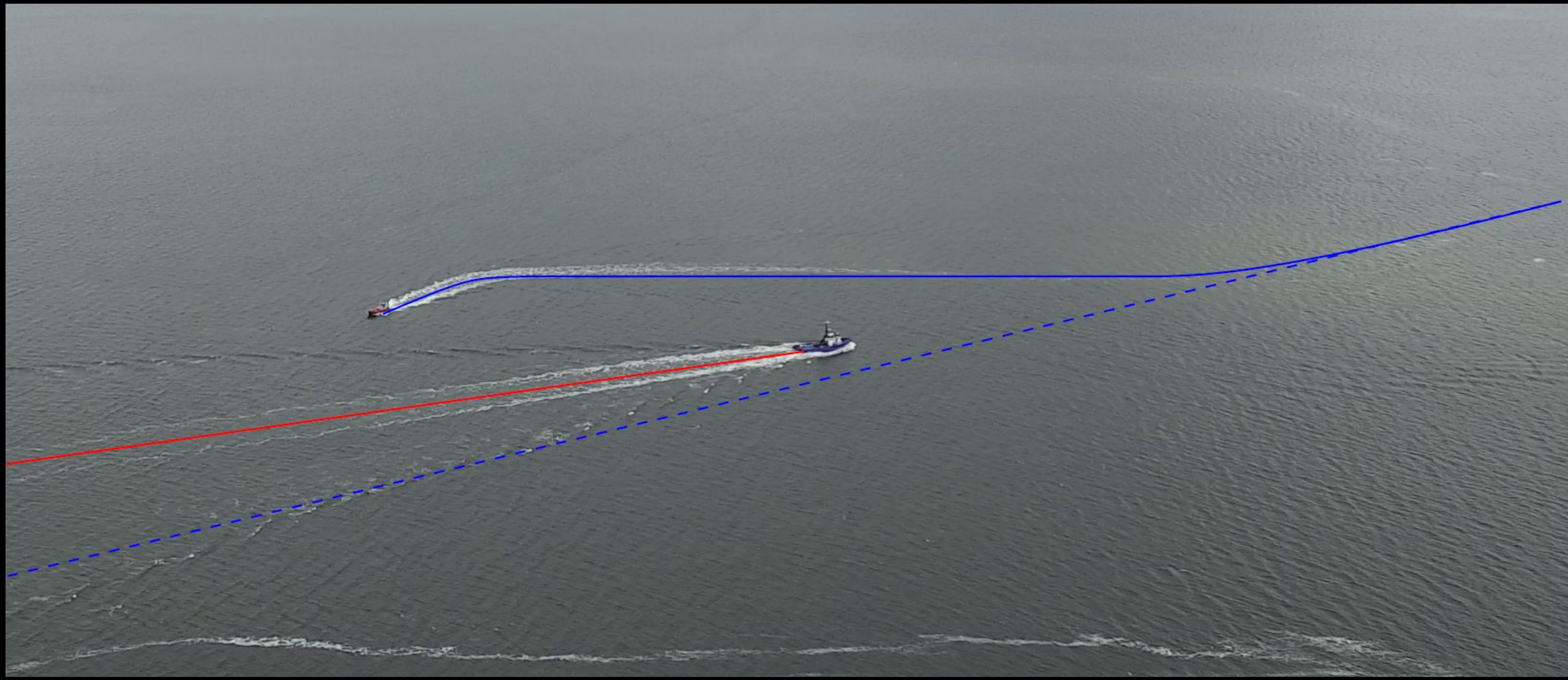

Autosea project – Sensor fusion and collision avoidance for autonomous surface vehicles

https://www.ntnu.edu/autosea/


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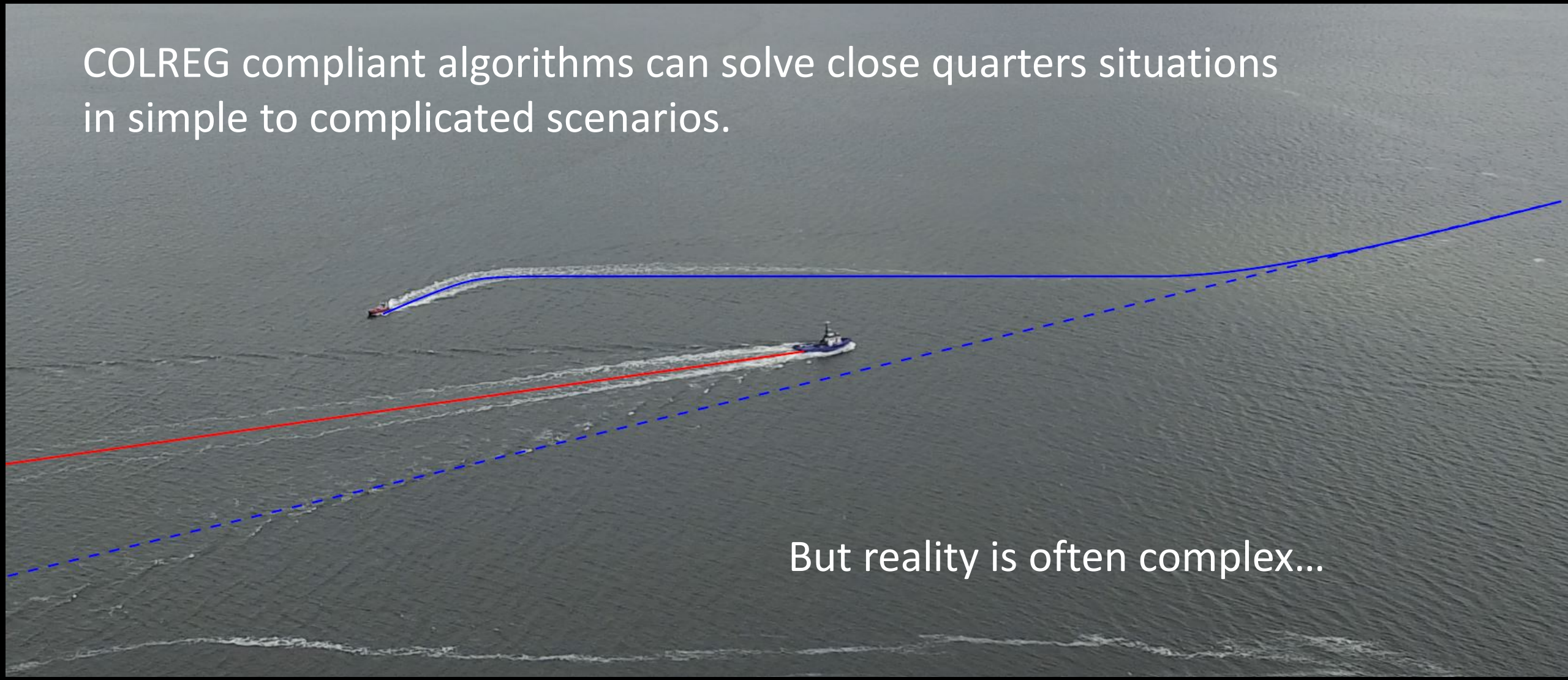
COLREG compliant algorithms can solve close quarters situations in simple to complicated scenarios.




Autosea project – Sensor fusion and collision avoidance for autonomous surface vehicles

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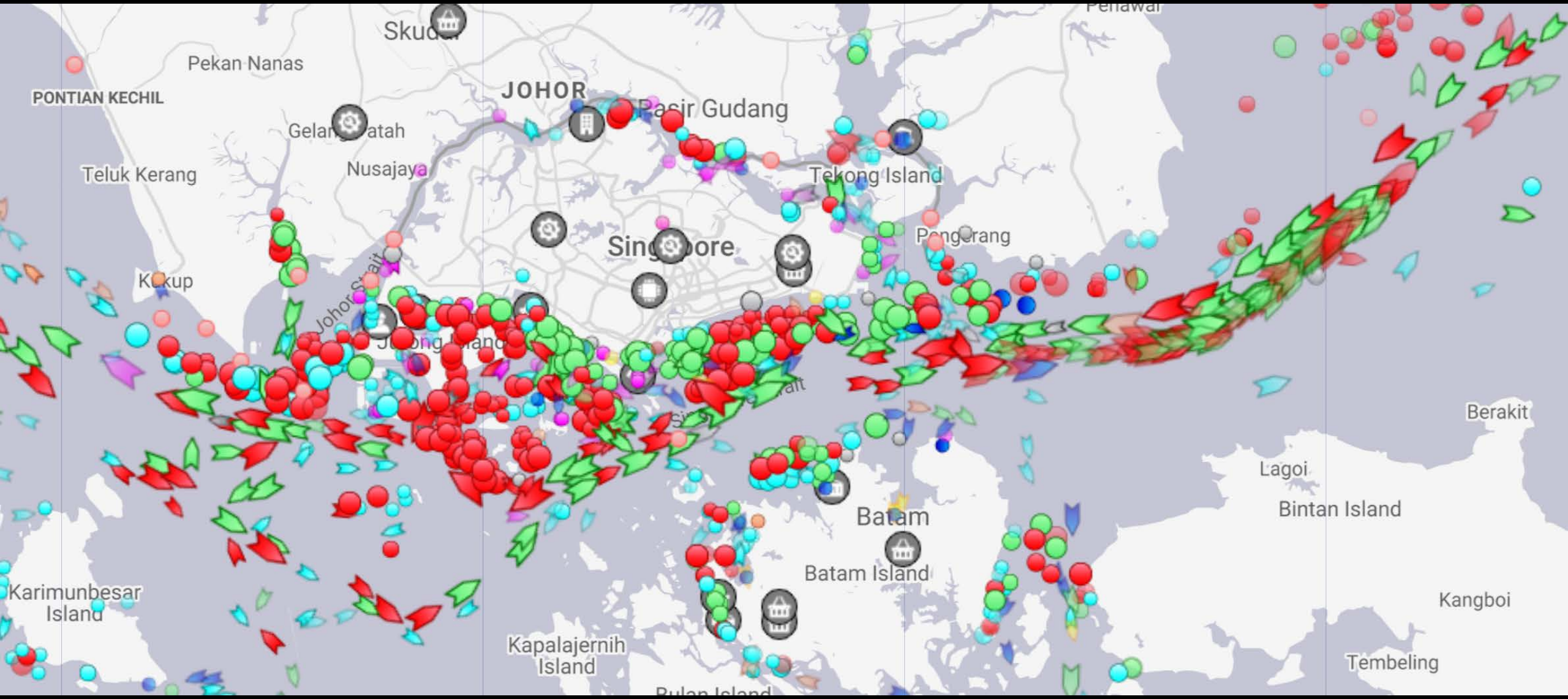
# **The complexity of the environment**: The traffic situation in Singapore Strait 2019-11-13, 2040 (ECT)




https://www.marinetraffic.com/en/ais/home/centerx:104.0/centery:1.2/zoom:10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# **The complexity of human behaviour**: Collision between *Huayang Endeavour* and *Seafrontier* 2017


MAIB SERIOUS MARINE CASUALTY REPORT NO 7/2018, *Collision between Huayang Endeavour and Seafrontier approximately 5nm west of Sandettie Bank, English Channel 1 July 2017*


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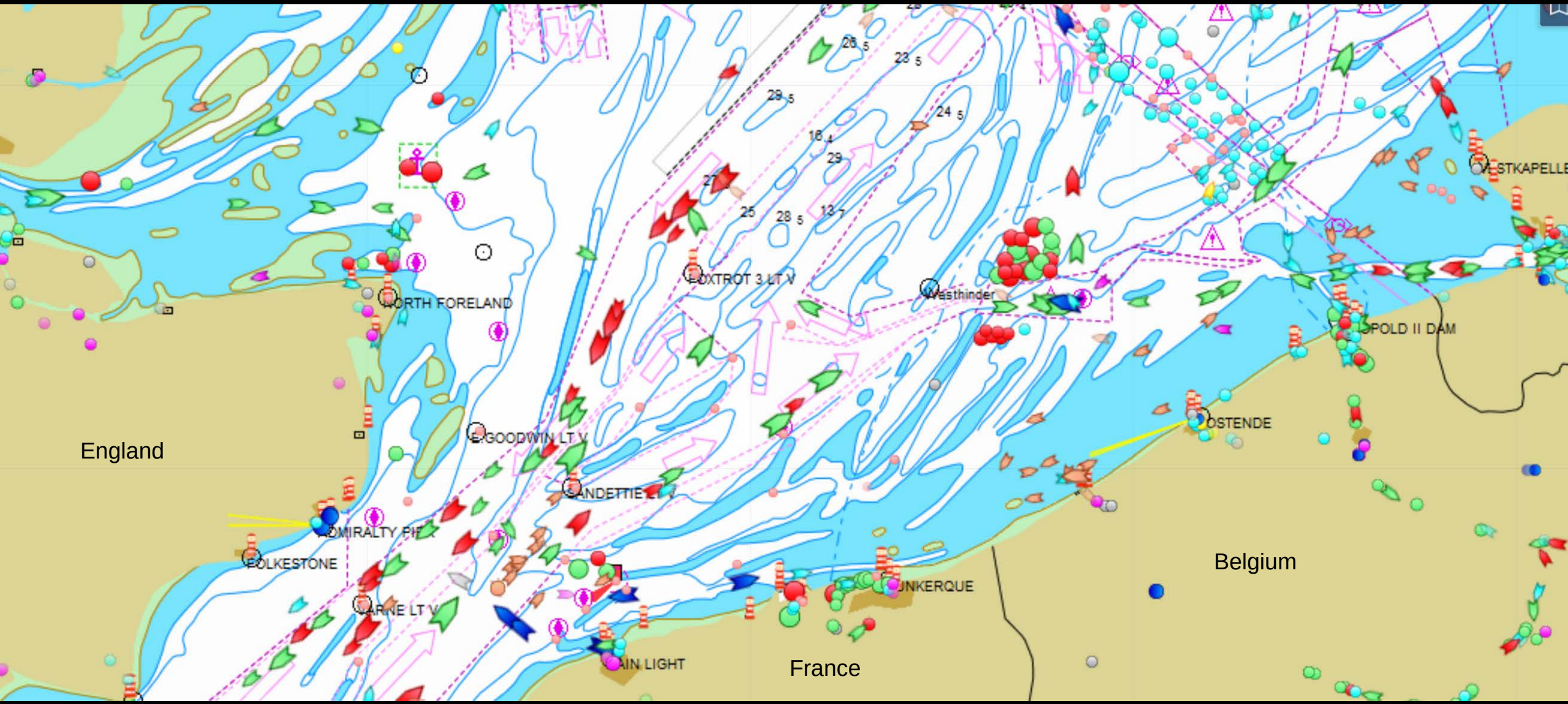


*https://www.marinetraffic.com/en/ais/home/centerx:1.8/centery:51.3/zoom:9*


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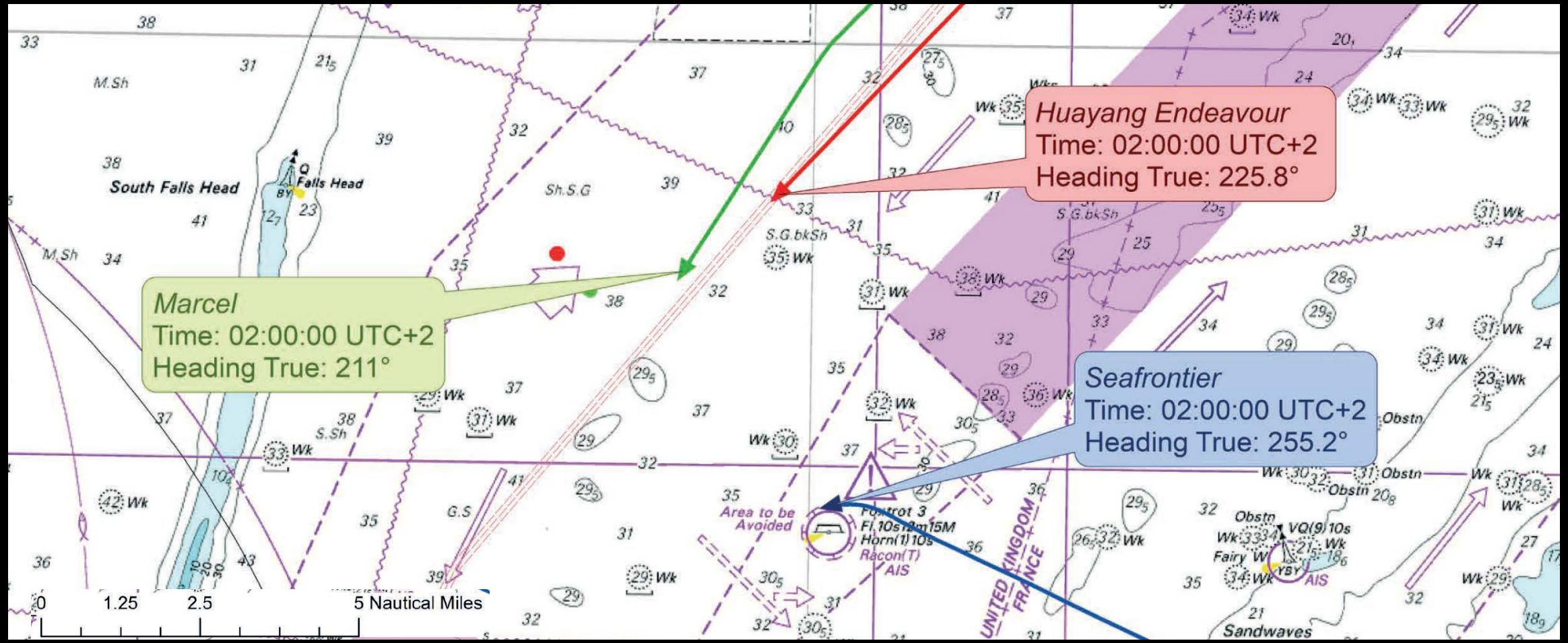


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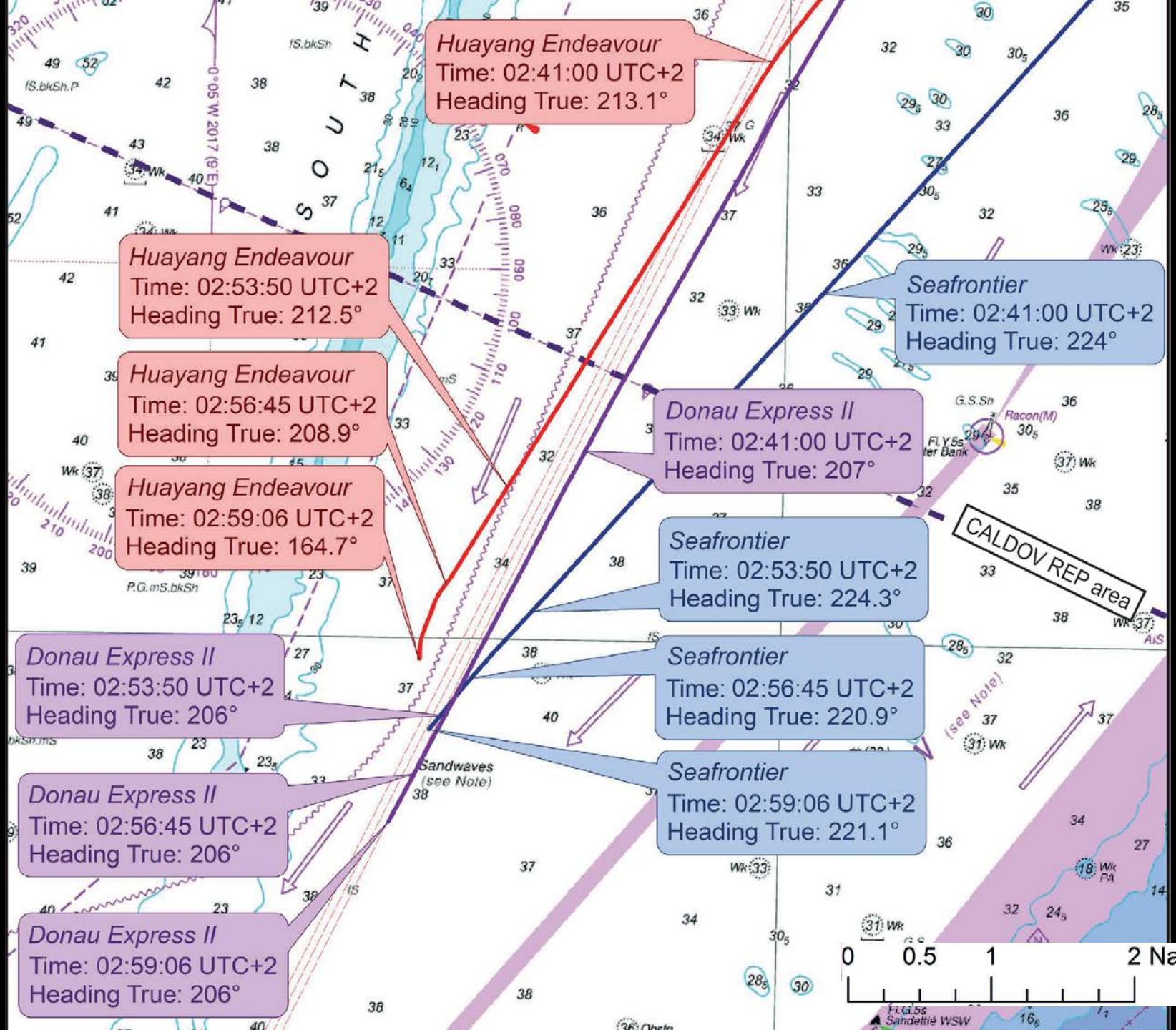
Huayang Endeavour
Time: 02:41:00 UTC+2
Heading True: 213.1°
Huayang Endeavour
Time: 02:53:50 UTC+2
Heading True: 212.5°
Huayang Endeavour
Time: 02:56:45 UTC+2
Heading True: 208.9°
Huayang Endeavour
Time: 02:59:06 UTC+2
Heading True: 164.7°
Seafrontier
Time: 02:41:00 UTC+2
Heading True: 224°
Donau Express II
Time: 02:41:00 UTC+2
Heading True: 207°
Seafrontier
Time: 02:53:50 UTC+2
Heading True: 224.3°
Seafrontier
Time: 02:56:45 UTC+2
Heading True: 220.9°
Seafrontier
Time: 02:59:06 UTC+2
Heading True: 221.1°
Donau Express II
Time: 02:53:50 UTC+2
Heading True: 206°
Donau Express II
Time: 02:56:45 UTC+2
Heading True: 206°
Donau Express II
Time: 02:59:06 UTC+2
Heading True: 206°
CALDOV REP area
Sandwaves
(see Note)
0 0.5 1 2 Nautical Miles

# **The complexity of human behaviour**: Collision between *Huayang Endeavour* and *Seafrontier* 2017

| | | |
|---|---|---|
| 0254:15 | *Huayang Endeavour* | Yah, err *Seafrontier*, what is your intention? |
| 0254:20 | *Seafrontier* | I should ask you what is your intention, you are overtaking me and not keeping me clear - what is your intention? |
| 0254:29 | *Huayang Endeavour* | Yah, I will overtake you on your starboard side, starboard side okay? |
| 0254:34 | *Seafrontier* | Alter your course to starboard side, I have a vessel on my port side, I cannot alter so much on my port side. I am giving some few degrees to my port side, I will give you some 4-5 degrees clearance but I cannot alter too much on my port side okay? |
| 0254:53 | *Huayang Endeavour* | Yeah, err port overtake is so near, so near. Is very dangerous |
| 0256:02 | *Seafrontier* | No, you have to keep me clear because you are overtaking me, you can reduce your speed, do you understand? |
| 0255:26 | *Huayang Endeavour* | Yeah okay, thank you thank you |

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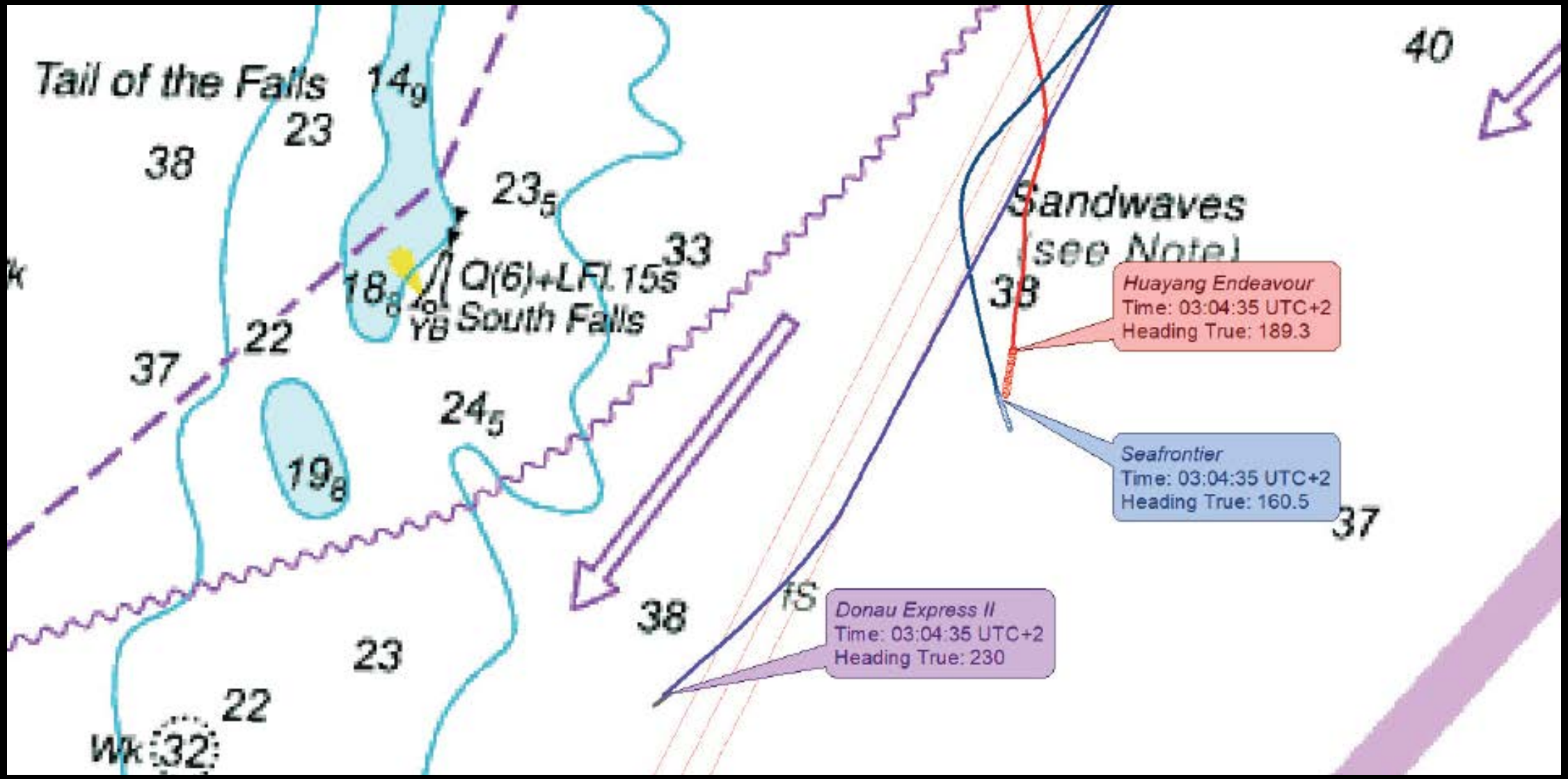


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## MAIB'S CONCLUSIONS

- It is considered very likely that a combination of fatigue and high mental loading would have affected Seafrontier's master's decision making and reaction times at the time of the accident.
- The lack of long-range scanning by Huayang Endeavour's bridge team led to a late attempt at collision avoidance through VHF communication.
- The VHF conversation between Huayang Endeavour and Seafrontier was confusing, did not use SMCP terminology, and resulted in the two bridge teams developing conflicting plans while believing that they understood the intentions of the other.
- Seafrontier's bridge team altered course to port without first assessing the available sea room astern.
- Neither vessel made sound signals, losing the opportunity to alert the other to their intentions.

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# Automation can make shipping safer

Fatigue and attention

Misunderstood communication

Situation awareness (SA)


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# Automation can make shipping less safe

Automation paradox

Automation bias

B*lack Swans*


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# Simplification of complexity (transparency)

- COLREGS
- Lights and signals
- Traffic separation
- AIS warning of autonomous ship
- Route exchange
- Simplified route exchange, intended route/moving havens


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# Should we develop machine-readable COLREGS?


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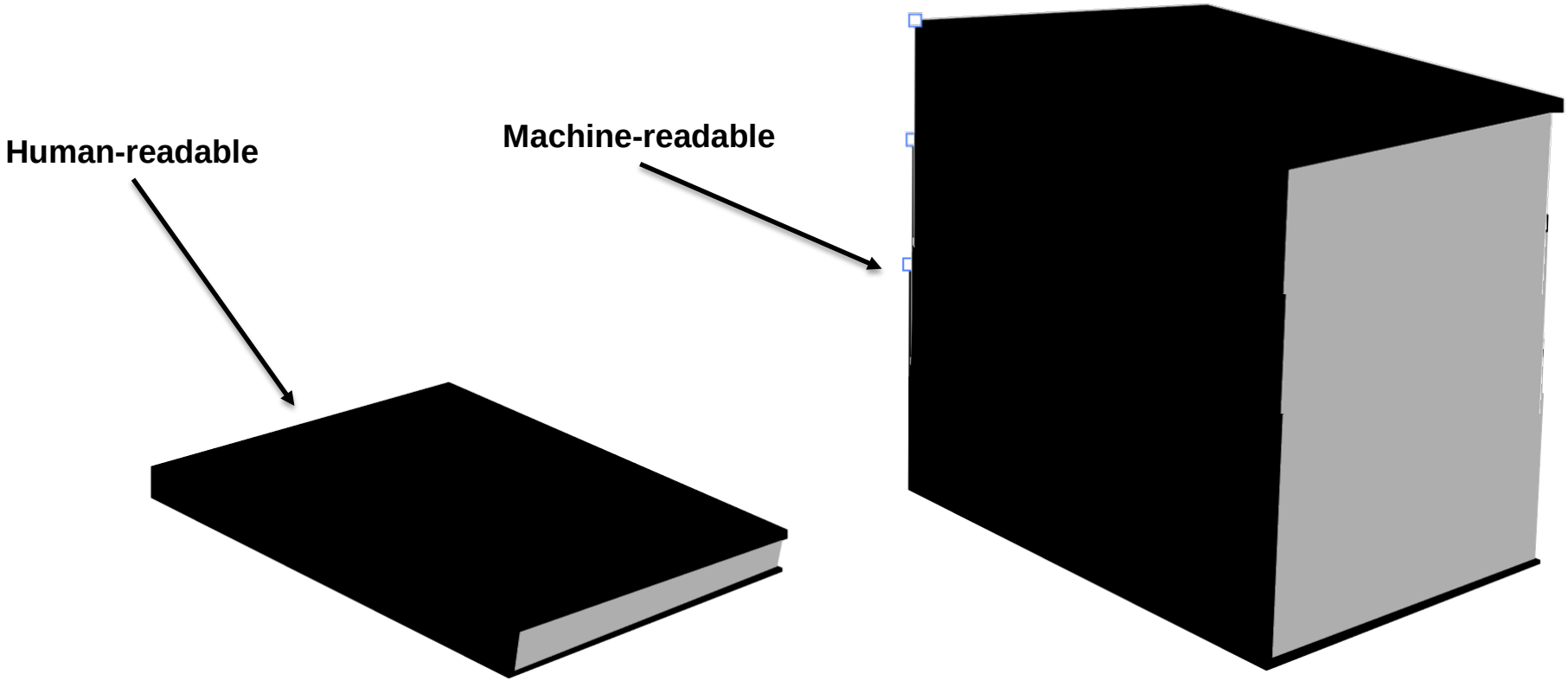



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# Lights and signals


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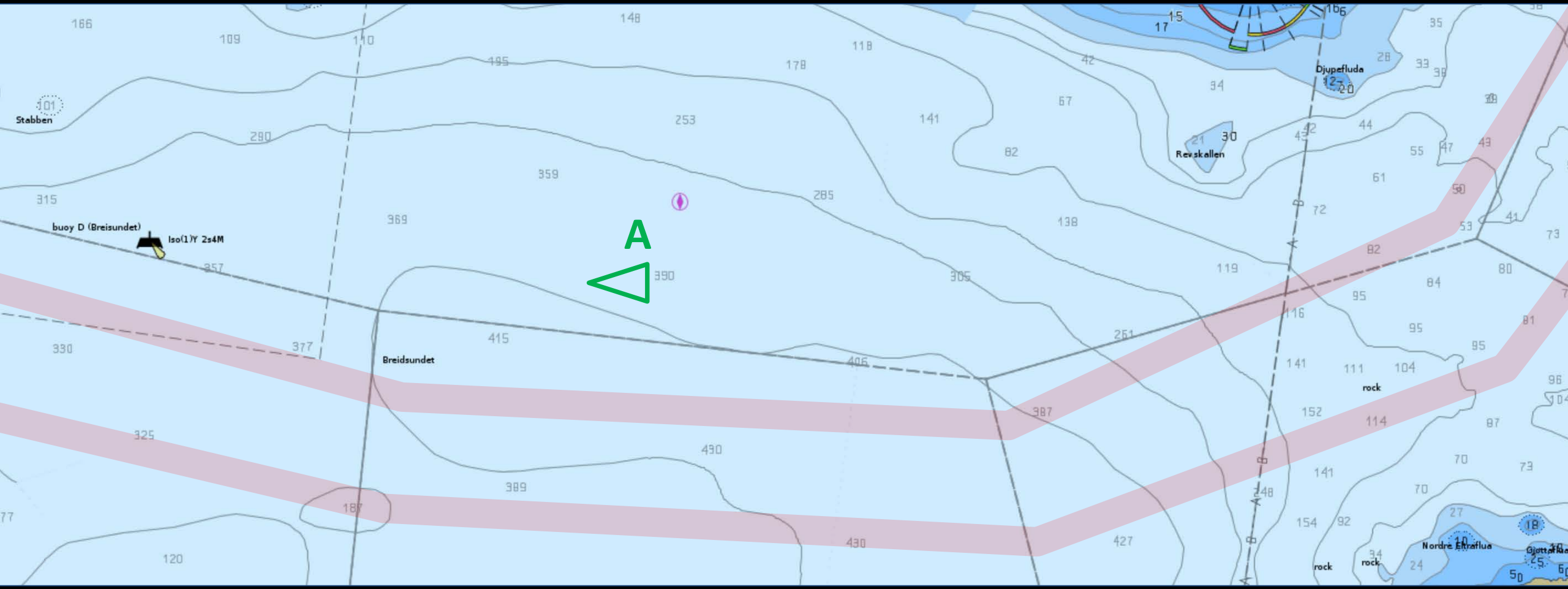
# AIS symbol



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Identification light for a ship in autonomous mode


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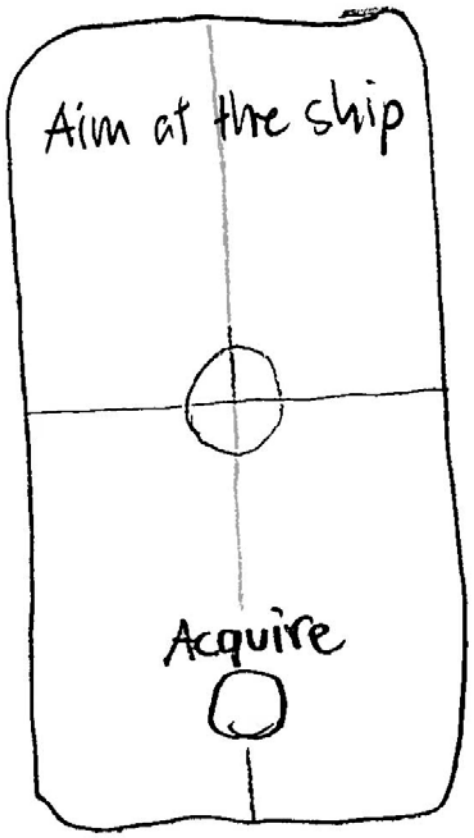
# “Have I been seen by the MASS?” Leisure boat app

Lights and signals

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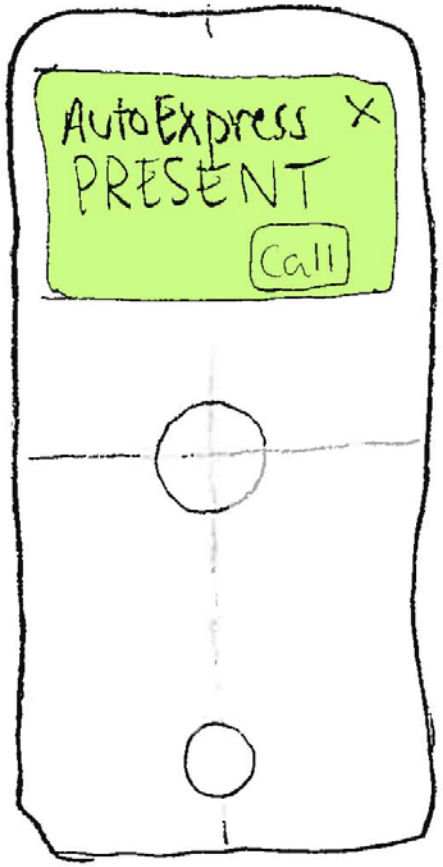
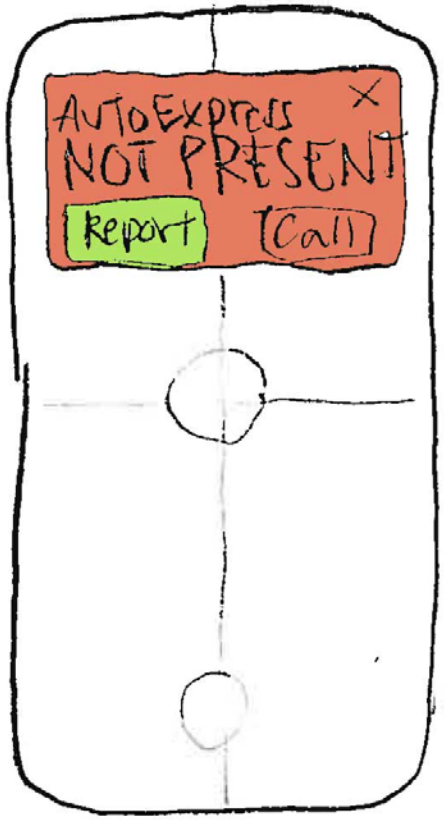



2.




3.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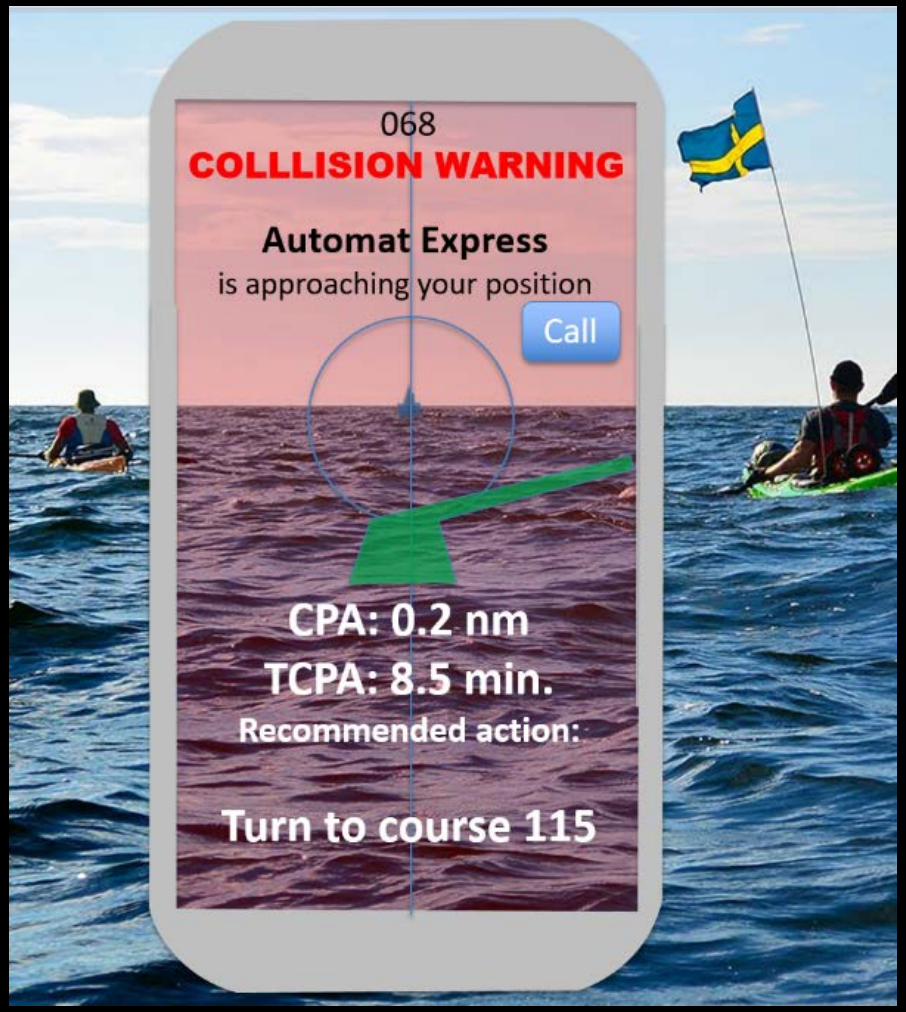
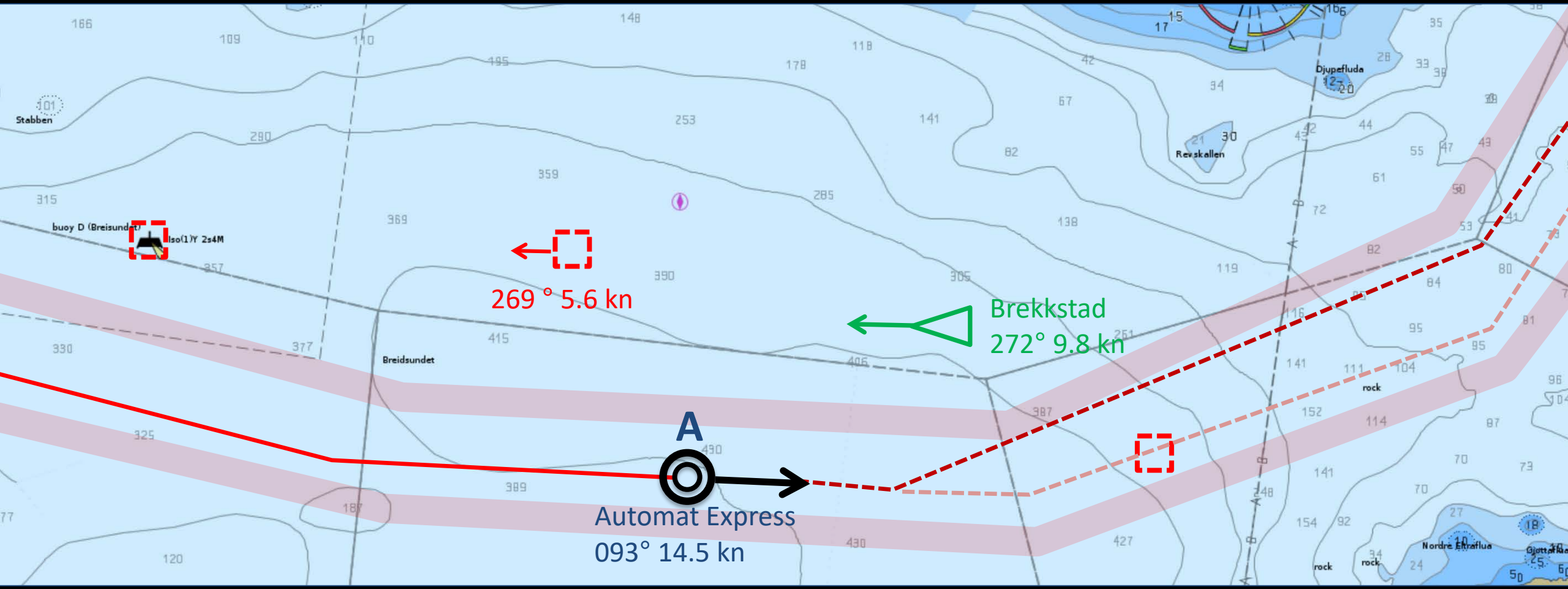
# “Have I been seen by the MASS?” Leisure boat app

Lights and signals



# ”Pick the MASS brain”: visit the MASS web page



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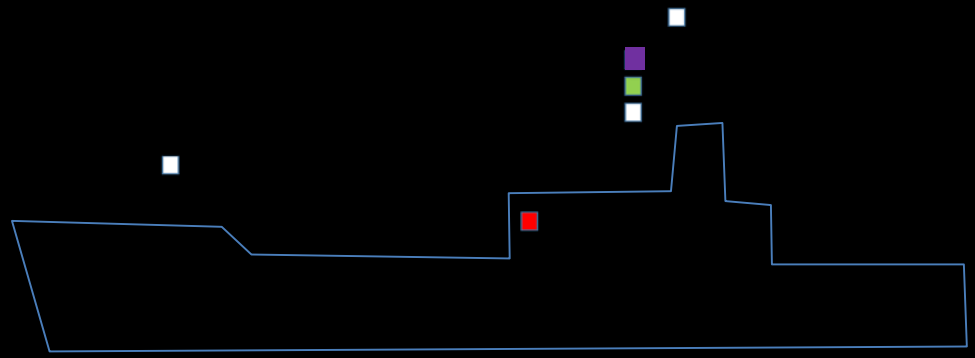
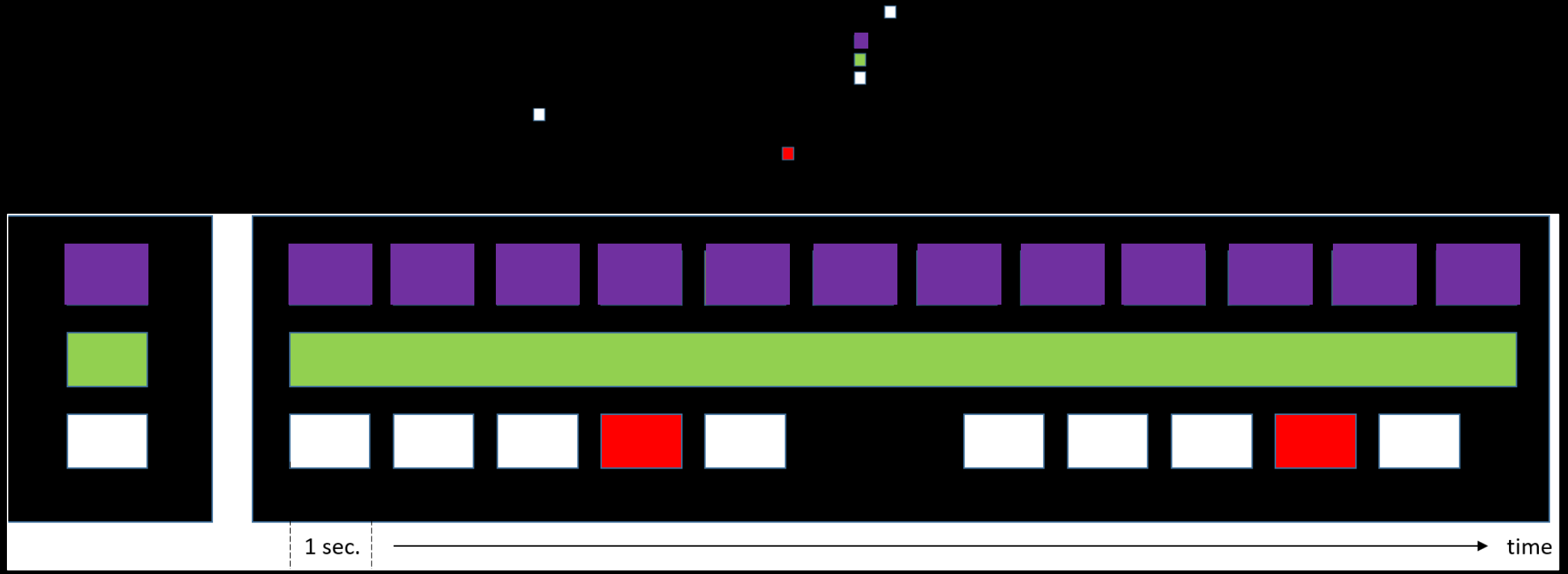
# Lights and signals

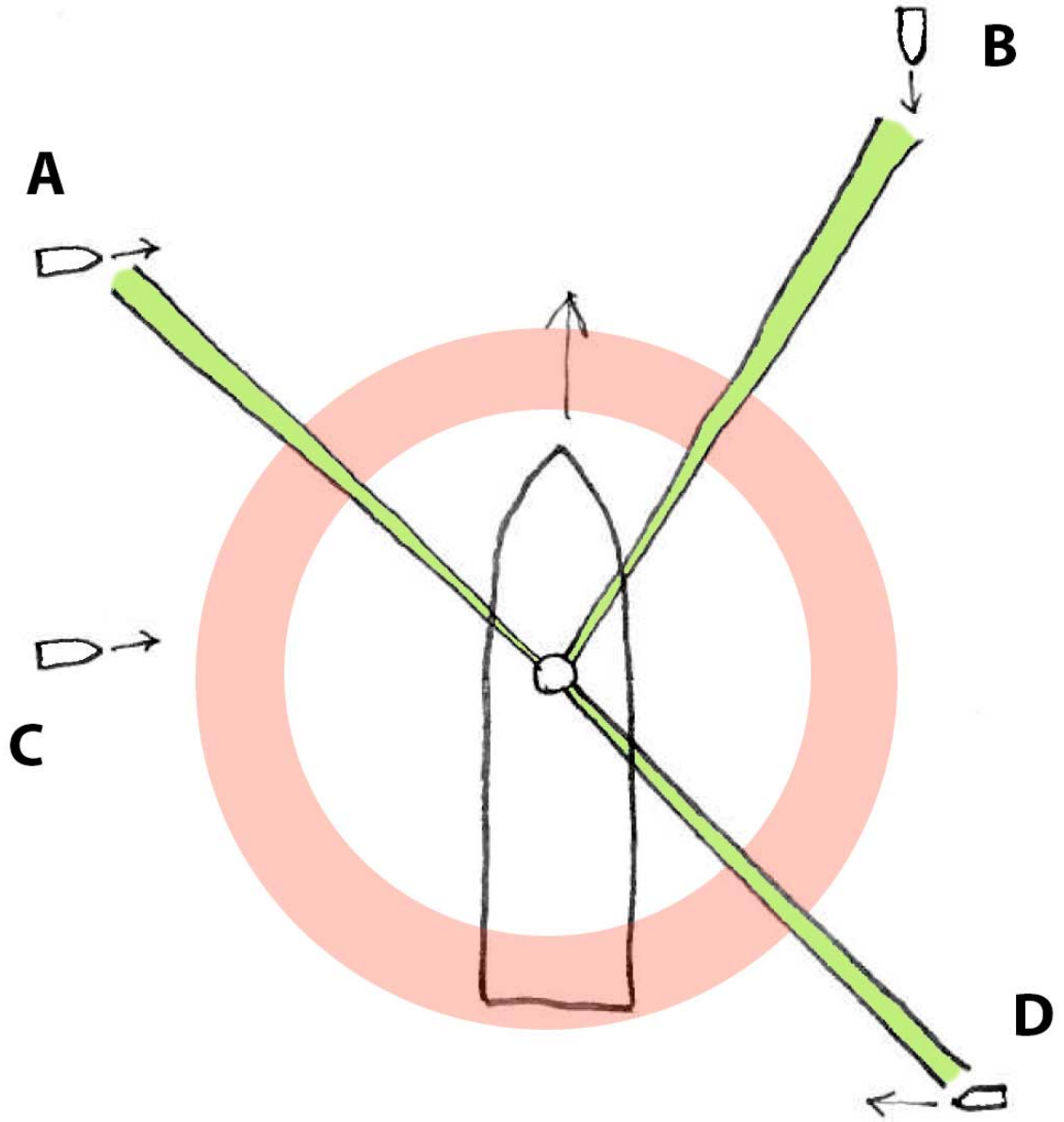


# Light signals for boaters without electronic aids

Lights and signals



Lights and signals



# Traffic separation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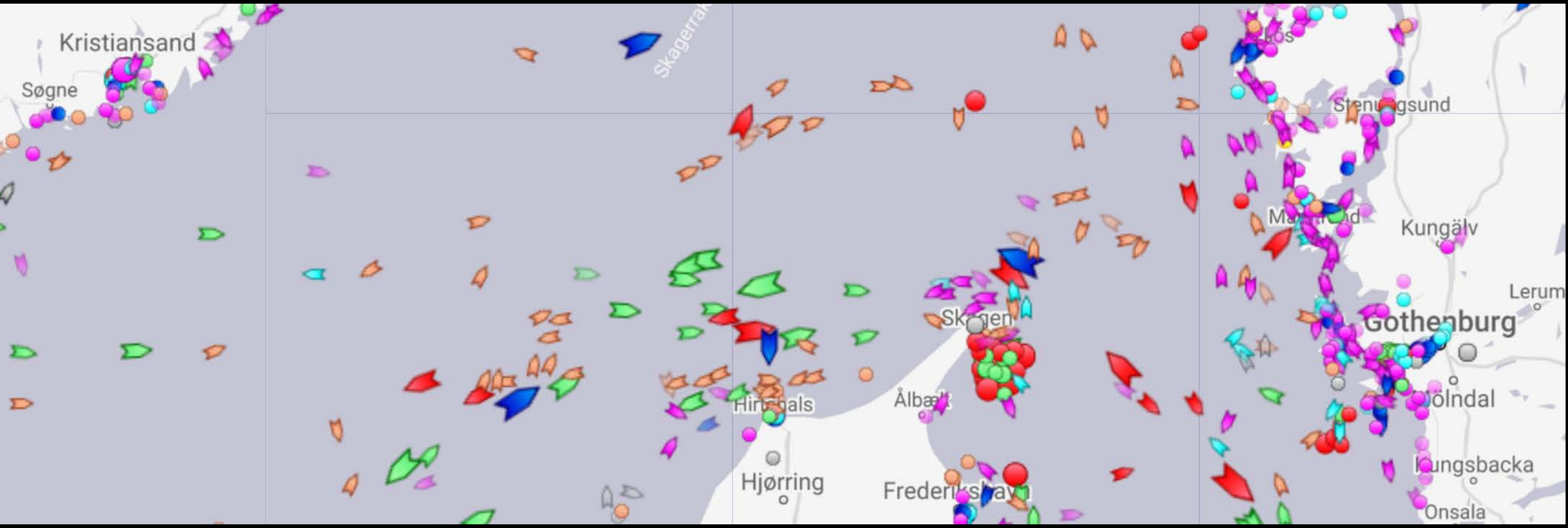
Traffic around the northern tip of Denmark, 2019-06-10



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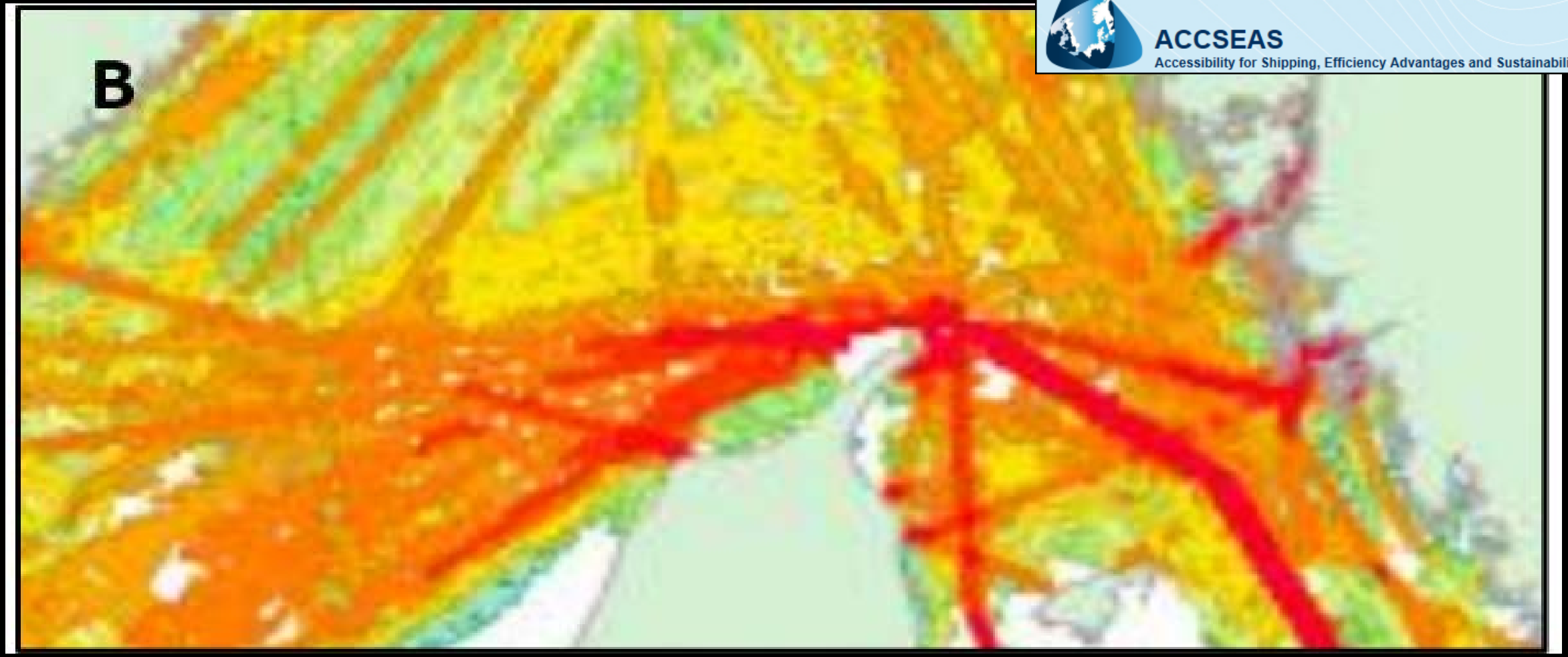
ACCSEAS
Accessibility for Shipping, Efficiency Advantages and Sustainability




*Traffic density map based on the number of AIS equipped ships during the whole of 2012 where red depicts the highest number of ships*

ACCSEAS. (2015). ACCSEAS Route Topology Model http://www.accseas.eu/publications/accseas-route-topology-model/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All routes that appear to be used by AIS carrying ships over the year 2012

ACCSEAS. (2015). ACCSEAS Route Topology Model http://www.accseas.eu/publications/accseas-route-topology-model/


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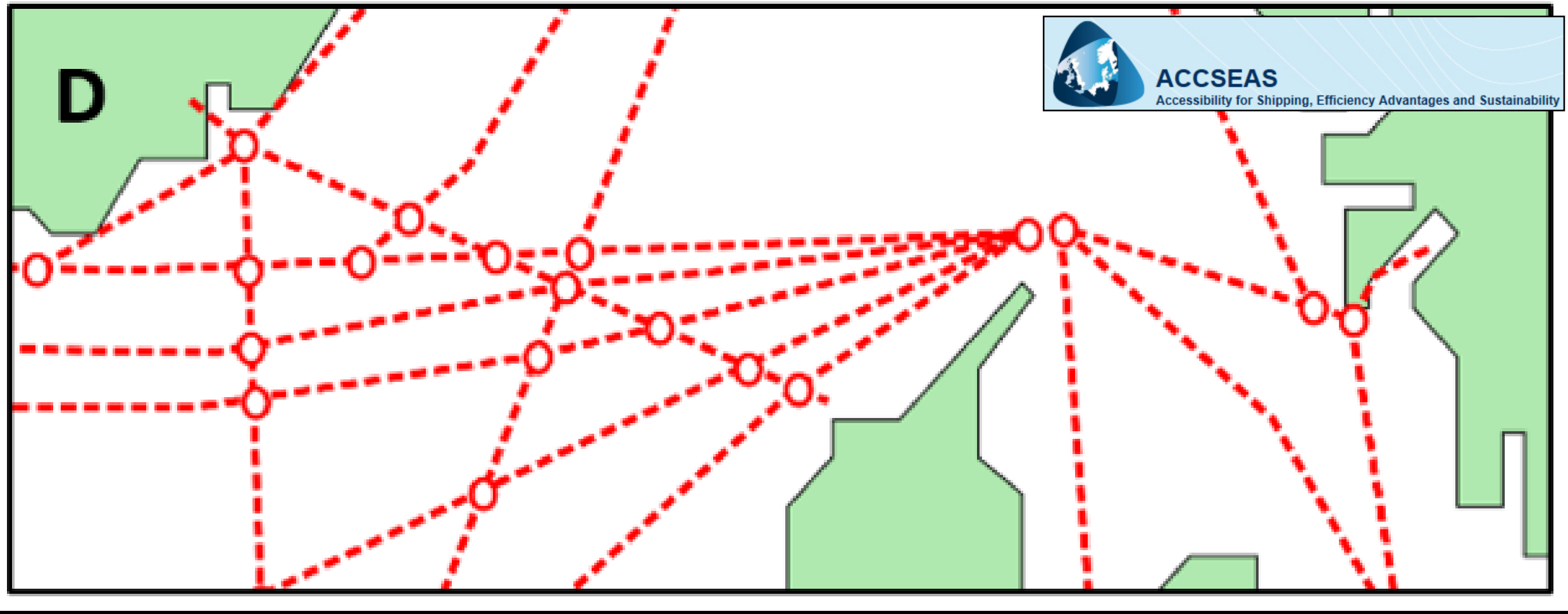


The final “motorway” route network topology derived in the ACCSEAS project

ACCSEAS. (2015). ACCSEAS Route Topology Model http://www.accseas.eu/publications/accseas-route-topology-model/


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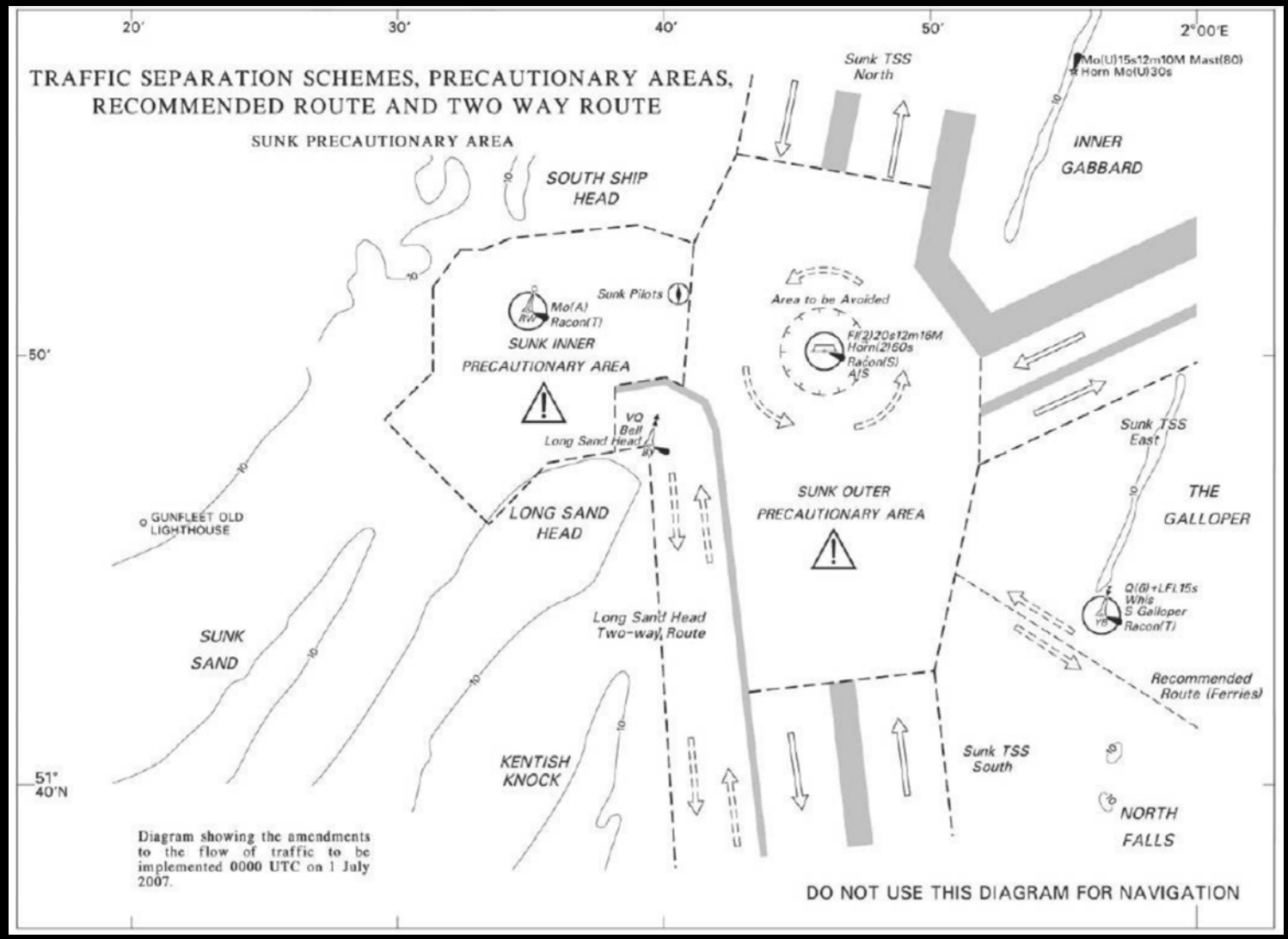


The Sunk Precautionary Area and the three Traffic Separation Schemes in the Northern Approaches to the Thames Estuary implemented in 2007

http://www.islandyachtclub.org.uk/sailing/sailing_navnotices%202.shtml



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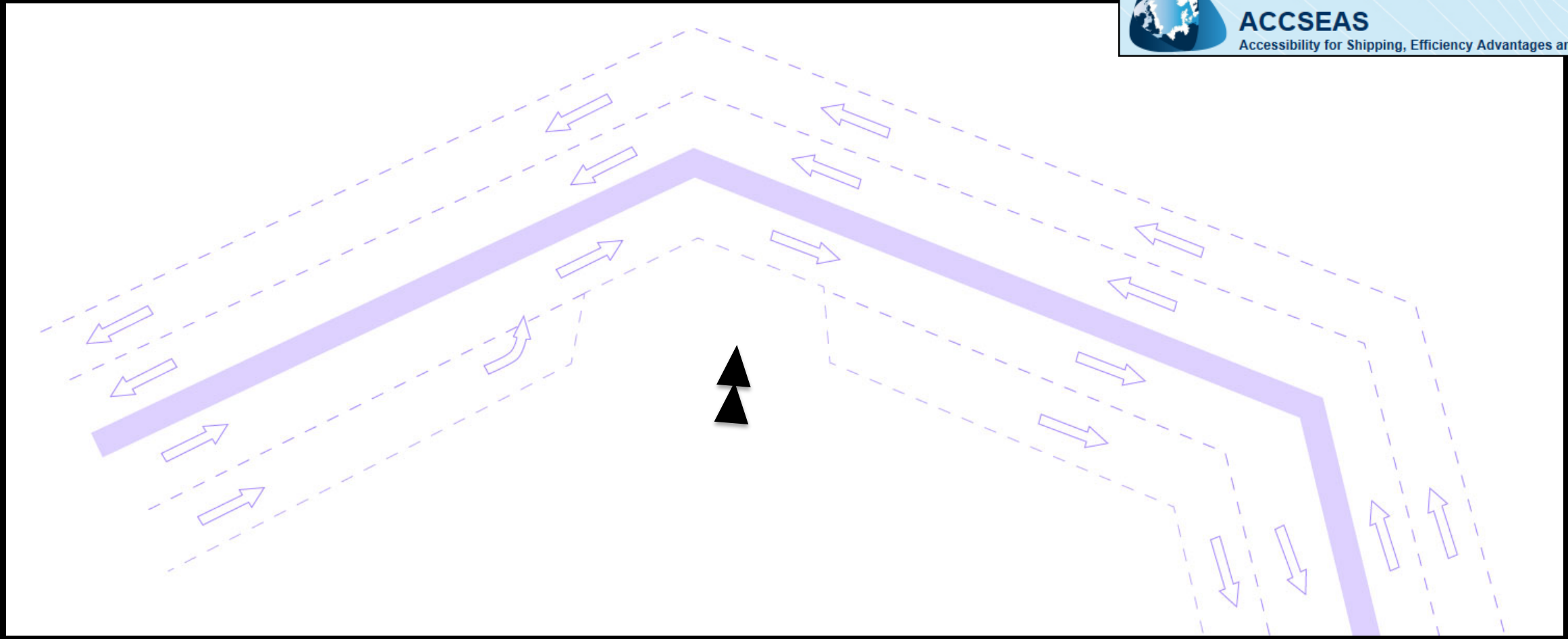

The Route Network Topology Model. Example of ”motorway” with multiple lanes

ACCSEAS. (2015). ACCSEAS Route Topology Model http://www.accseas.eu/publications/accseas-route-topology-model/


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# E-Navigation

Route exchange
Intended  routes
Moving havens


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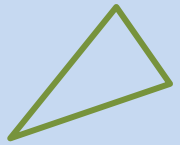

A

Own ship



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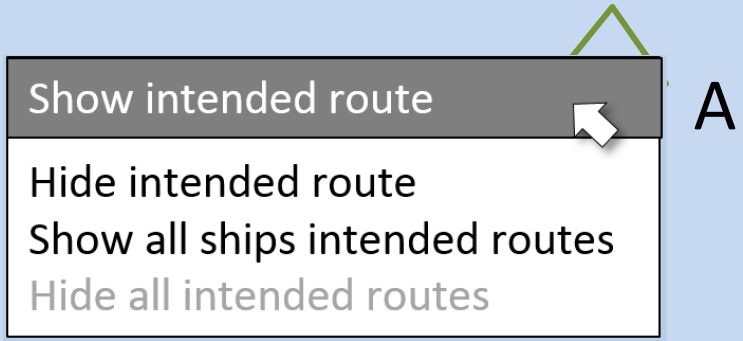



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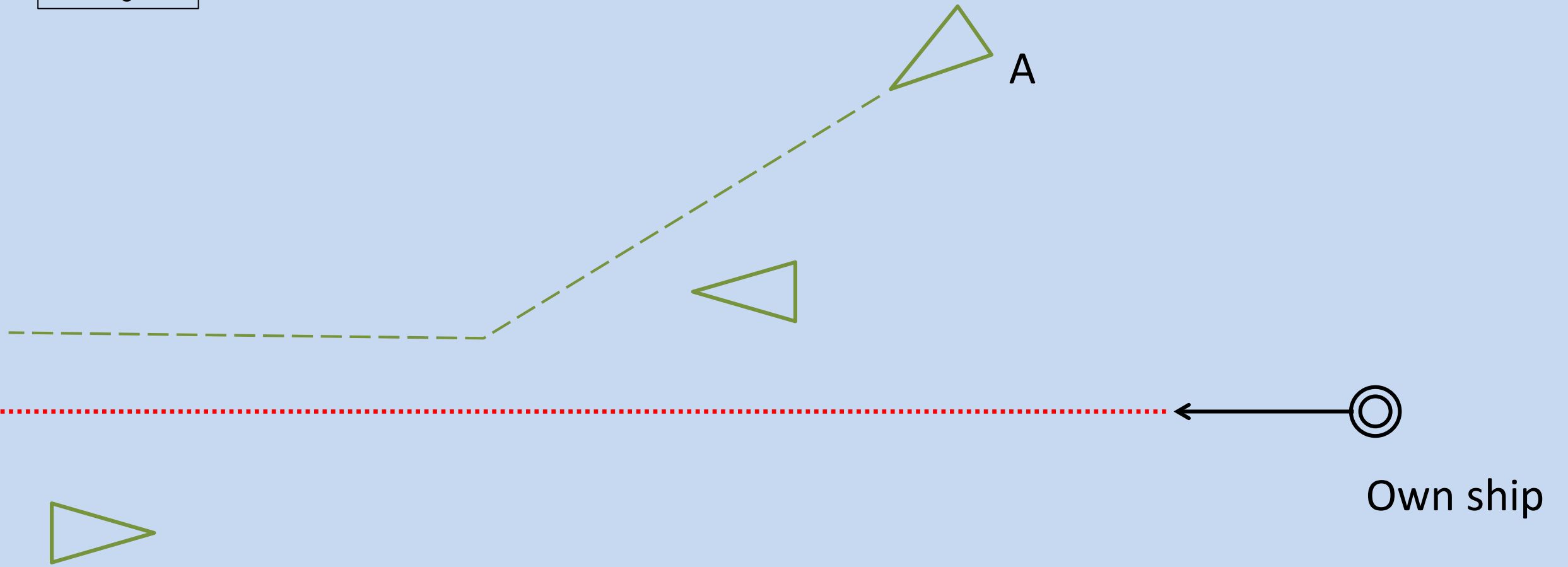
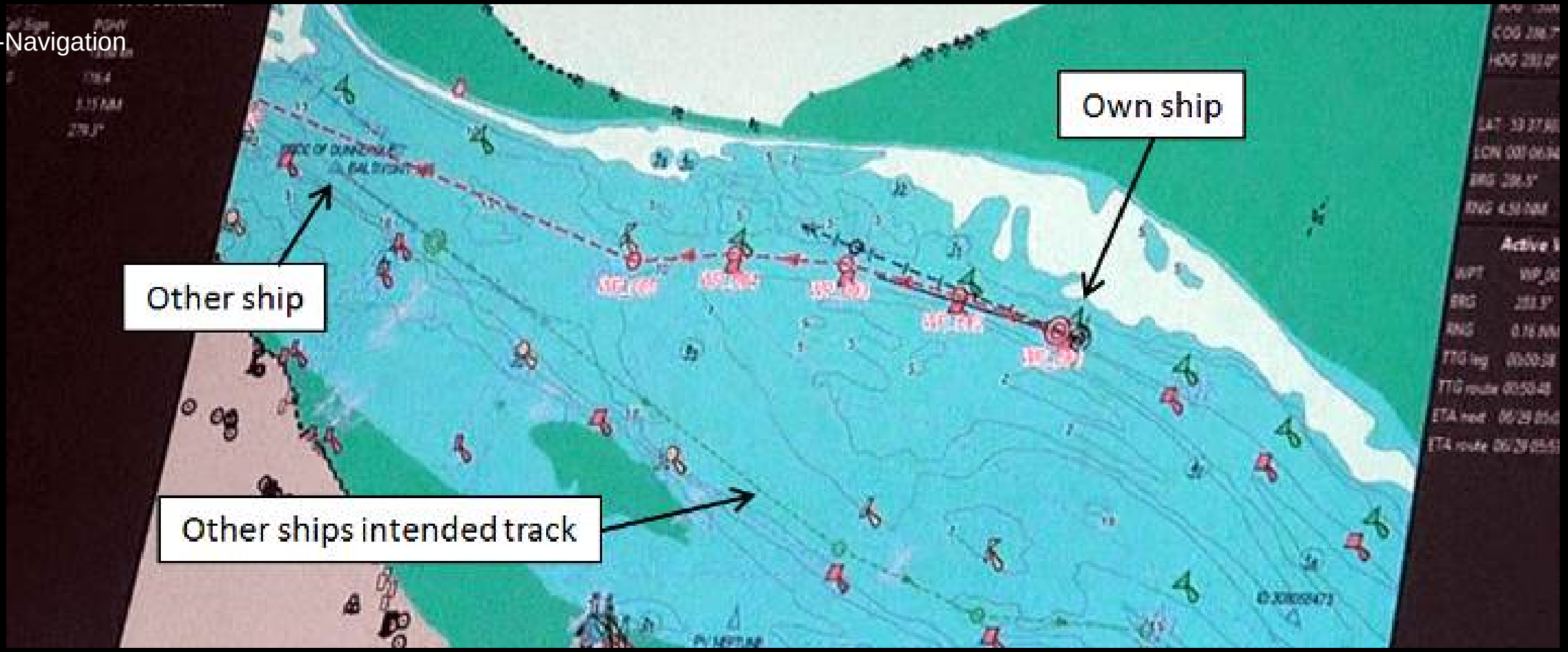

A
Own ship




Porathe, T. (2012). Transmitting intended and suggested routes in ship operations: cognitive off-loading by placing knowledge in the world. Work, 41 ( Supplement: 1 ) pp. 4873-4878.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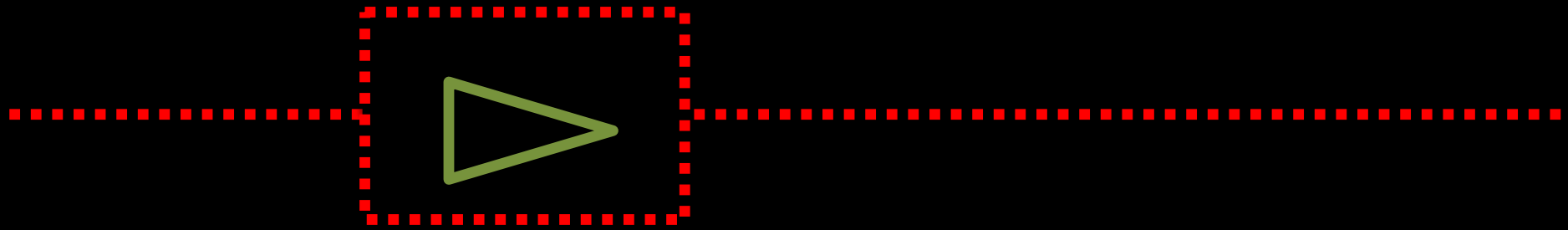
# Moving havens

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KYSTVERKET

# Digital rutetjeneste - routeinfo.no

Den digitale rutetjenesten er tilgjengelig for fartøy som anløper havner i farvannet mellom svenskegrensen i øst og Haugesund i sørvest. Tjenesten blir trinnvis gjort tilgjengelig fra sør til nord og vil dekke hele kysten i løpet av 2020.



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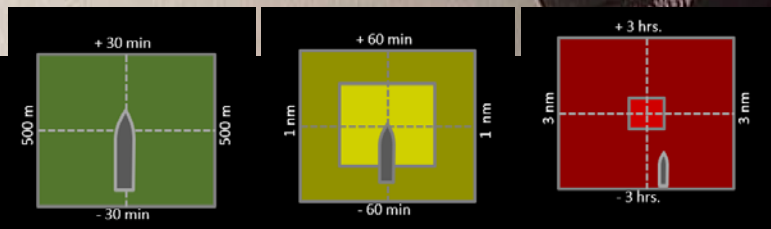
Ship

Moving haven

Conning window




Safe haven in ECDIS during a technical tests Korea 2013

On track
On time

On track
Small delay

Off track sb
Large delay



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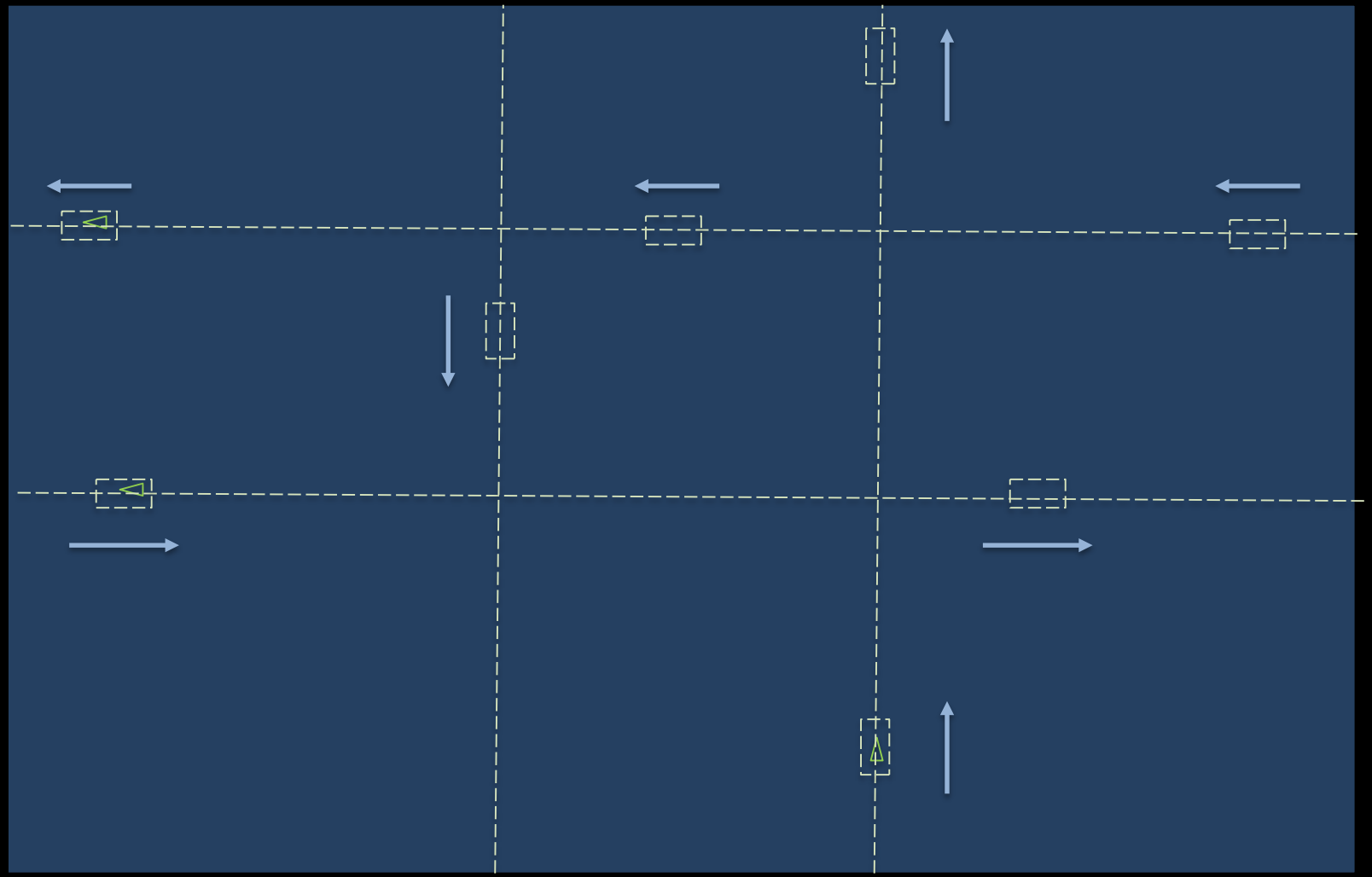
In congested waters, Moving haves can be used as as predefined slots moving as a ”conveyor belt” where ships catch an empty slot. The slot system is coordinated with crossing traffic.

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# Conclusions

- We need to use all available methods we have to simplify the environment and interaction with other vessels in order to reduce complexity. E.g.

- COLREGS
  Lights and signals
  Traffic separation
  AIS warning of autonomous ship
  Route exchange, intended route/moving havens


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